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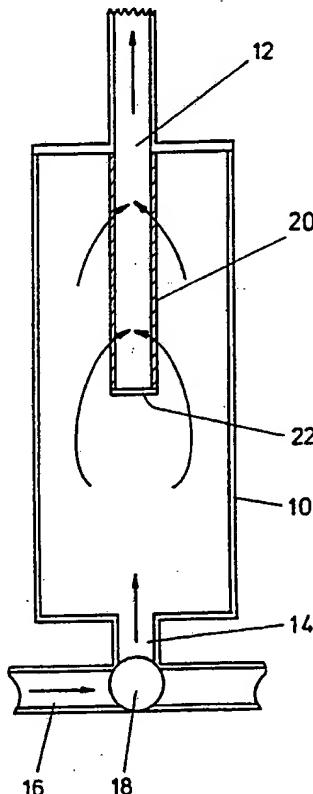
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(54) Title: FILTERING ELEMENT AND MACHINE FOR ITS MANUFACTURE

(57) Abstract

A filtration apparatus comprises a filter element in the form of a helical coil tension spring (20) suspended freely from one of its ends. The spring rate of the wire, from which the coil is wound, varies progressively along the length of the coil, such that the adjacent turns of the coil are held in contact with each other with a contact pressure which is uniform along the length of the coil. A machine is also disclosed, which may be used to make the filter element.



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Filtering Element and Machine for its Manufacture

This invention relates to a filtering element for an apparatus used to filter water or other fluids. This invention also relates to a machine for forming helical springs, which may be used as the filtering element.

5 A known type of filtration apparatus comprises a flow duct housing a filter element consisting of a wire wound into a helical coil in the form of a compression spring: the filter element is oriented with its axis vertical and its top end fixed around a flow outlet from the duct. The bottom end of
10 the filter element is closed by a plate, which, in use of the apparatus, is urged upwards to hold the adjacent turns of the coil construction in contact with each other. Water or other fluid to be filtered is passed into the duct through its lower end and passes between the adjacent coil turns of the filter
15 element, from the space surrounding the coil to the space within the coil, and then out through the top end of the filter element.

The filtrate is retained on the coils of the filter element, but is removed periodically by backwashing. For this
20 purpose the support at the bottom end of the filter element is relaxed to allow the element to extend under its own weight, then a backwash flow is introduced through the outlet at the top of the duct, to pass between the coils of the filter element and wash away the retained filtrate. However, when the
25 filter element is extended under its own weight, the separation between its adjacent turns progressively reduces from the top to the bottom of the element: as a result the effectiveness of the backwashing process varies along the length of the element.

I have now devised a filter element which can be
30 backwashed more effectively and in less time than the filter element described above.

In accordance with this invention, there is provided a filter element which comprises a wire or other elongate element wound into a helical coil in the form of a tension spring with
35 adjacent turns in contact with each other when the coil is suspended freely from one of its ends.

In use the filter element is suspended from its top end without any support for its bottom end, yet the adjacent coils

remain in contact or contiguous with each other to provide for filtering.

The bottom end of the filter element coil is closed: during backwash, the backwash flow passing down within the coil 5 impinges on the bottom end closure with the effect of extending the coil and the backwash passes radially outwards between the adjacent turns of the coil to remove the filtrate retained on the filter element. In particular, a resonant oscillation of the coil is set up, with adjacent turns impacting against each 10 other to enhance removal of the filtrate.

Preferably the stiffness or spring rate of the wire (or other elongate element) varies progressively along the length of the helical coil, being stiffer towards the one end (i.e. the end from which the coil is suspended when in use). This 15 variation ensures that each turn of the coil is held up against the next turn above with a substantially uniform contact pressure, regardless of the number of turns below it (and therefore the weight pulling that turn downwards). Further, when the coil is extended under a steady tension, the 20 separation between adjacent turns of the coil is substantially uniform from the top to the bottom of the coil.

The wire (or other elongate element) from which the coil is wound is preferably rectangular in section and it is wound on edge (i.e. with its opposite edges facing radially 25 inwards and radially outwards). In order to define a gap between adjacent turns of the coil, preferably one side of the wire (or other elongate element) is formed with a series of spaced projections. In one embodiment, the wire has a flat side and an opposite side formed with an apex along its length: 30 the flat side may be grooved or knurled or provided with a series of spaced projections to rest against the apex of the adjacent turn.

The coil may be wound from a metal (e.g. stainless steel) wire or from a plastics element of suitable springiness.

35 The presently known processes for forming helical springs are relatively complex and are limited as regards the construction of springs which can be made.

I have now devised a machine which enables a wide variety of different forms of helical spring to be made in a

simple manner, including helical springs which can be used as the filter element described above.

In accordance with this invention, there is provided a machine for forming a helical spring, comprising a mandrel, a 5 guide for guiding wire or other elongate element tangentially to the mandrel, drive means upstream of the mandrel for advancing the wire to the mandrel, and a forming means which forms the wire around the mandrel as the wire is advanced.

Preferably the forming means engages the advancing wire 10 over an arc of approximately 90° following the tangential point of contact of the wire with the mandrel. Preferably the forming means comprises two rollers, one just downstream of the tangential point of contact of the wire with the mandrel, and the other at a position 90° from that point. Preferably a 15 third roller is included in the wire guide, just prior to the tangential point of contact of the wire with the mandrel, to take the reaction force of the wire as it is bent by the forming means.

Preferably the forming means deflects the wire out of 20 the vertical plane in which it lies as it passes through the wire guide (i.e. the plane to which the axis of the mandrel is perpendicular). Preferably the forming means is adjustable to adjust the angle of this deflection: the setting of this angular deflection determines the characteristics of the 25 spring. Preferably means are provided so that the adjustment can be made whilst the machine is running: in this way a spring can be made which varies in stiffness or spring rate along its length. The spring may be a compression spring, in which its adjacent turns are separated by gaps, or a tension spring, in 30 which its adjacent turns are urged into contact with each other.

The machine may form a spring from fully annealed round-section wire (e.g. stainless steel) without any subsequent heat treatment. Alternatively the machine may form 35 a spring from an elongate element or filament of plastics material.

The round-section wire may be converted to a rectangular or other section by passing through a co-operating pair of profile rollers on its way to the wire guide:

preferably these profile rollers are driven and form the drive means which advances the wire through the wire guide and to the mandrel. The profile rollers impart a degree of work hardening to the wire. Alternatively or in addition, a degree of work hardening may be imparted by applying a brake to the wire upstream of the profile rollers or other drive means, or by passing the wire through a die (to reduce its diameter) upstream of the profile rollers or other drive means.

5 Embodiments of this invention will now be described by 10 way of examples only and with reference to the accompanying drawings, in which:

FIGURE 1 is a schematic section through a filtration apparatus which includes a filtering element in accordance with this invention, the filtering element being shown at rest;

15 FIGURE 2 is a similar section through the filtration apparatus, showing the filtering element extended during backwash;

FIGURE 3 is an enlarged view of part of one form of wire from which the filtering element may be wound;

20 FIGURE 4 is an enlarged section through two adjacent turns of a filtering element coil wound from another form of wire.

FIGURE 5 is an enlarged section through two adjacent turns of a filtering element coil wound from a further form of 25 wire;

FIGURE 6 is a schematic view of a pair of driven profile rollers of a spring forming machine in accordance with this invention;

FIGURE 7 is a schematic front view of the forming head 30 of the machine; and

FIGURE 8 is a section on the line III - III of Figure 7.

Referring to Figure 1 of the drawings, there is shown 35 a filtration apparatus which comprises a duct 10 which is closed at its top and bottom but has an outlet 12 in its top and an inlet 14 in its bottom. A filter element 20 of the apparatus comprises a wire (or other elongate element of appropriate springiness) wound into a helical coil in the form of a tension spring: the filter element 20 is suspended by one

of its ends from the closed top of the duct 10, being attached to the top around the outlet 12, to adopt a vertical orientation.

As mentioned above the filter element 20 is in the form 5 of a tension spring: every pair of adjacent turns are in contact with each other when the coil is suspended freely from its one end as shown, i.e. without support for its bottom end. The stiffness or spring rate of the wire varies progressively 10 along the length of the coil, the stiffness being greater towards the top end. This variation ensures that each turn of the coil is held up against the next turn above with a contact pressure which is substantially uniform from one end of the coil to the other: thus the stiffness of the wire towards the top end of the coil is greater, to maintain this uniform 15 contact pressure despite the greater number of turns below (and therefore the weight pulling downwards on the respective turn). The bottom of the coil 20 is closed by a disc 22 attached to it, forming a counterbalance weight which therefore determines the contact pressure between adjacent turns of the coil 20: 20 this counterbalance weight may be sufficient to reduce the contact pressure between adjacent turns of the coil to substantially zero in the at rest condition, although the adjacent turns still remain in contact.

In use of the apparatus for filtering, water or other 25 fluid to be filtered is passed along an inlet pipe 16 and a diverter valve 18 into the duct 10 through its inlet 14. The fluid then passes between adjacent turns of the coil 20, into the space within the filter element, and finally out of the apparatus through the outlet 12. Filtrate is retained on the 30 turns of the filter element: a layer of filtrate builds up on the filter element between the adjacent turns, and causes an extension of the coil 20.

Filtrate built up on the filter element is removed periodically by backwashing. Thus a backwash flow of water or 35 other fluid is passed through the outlet 12 of the apparatus and into the space within the filter element coil 20: this backwash flow impinges on the closure disc 22 at the bottom of the coil 20, with the effect of extending the coil downwards as shown in Figure 2. The backwash flow passes radially

outwards between the adjacent turns of the coil to remove the filtrate from the coil, and passes out of the apparatus through the inlet 14 and a waste pipe 19 via the diverter valve 18. The backwash flow sets up a resonant oscillation of the coil, 5 with a travelling wave moving in alternate directions along the coil and being reflected at the opposite ends, causing the adjacent turns to impact against each other. The filtrate is thus removed very effectively from the coil 20.

Preferably the coil 20 is wound from a wire (or other 10 elongate element) of rectangular cross-section, for example having a width 3 times its thickness, the wire being wound on its edge. One of the major surfaces of the wire is formed with a series of spaced projections spaced along its length, e.g. transverse ribs 24 as shown in Figure 3. In another form which 15 is shown in Figure 4, the wire has one flat major surface 26 and its other side is formed with a longitudinal apex 28 and surfaces inclining from this apex to its opposite edges: the flat surface 26 may be formed with a series of spaced projections along its length, to contact the apex of the 20 adjacent turn, or the flat surface 26 may be transversely grooved or knurled. In a yet further form which is shown in Figure 5, the wire has one flat major surface 30 and its other side comprises a domed longitudinal apex 32 joined by a narrow flat margin 33 to one edge 34 and joined by a narrow flat 25 margin 35 and an inclined surface 36 to the opposite edge 37: this wire is wound with the wider edge 34 radially inwards.

Referring to Figures 6 to 8 of the drawings, there is shown a machine which forms a spring, and for example may form the filter element of Figures 1 and 2. The machine forms a 30 spring from fully-annealed round-section wire W in one pass of the wire through the machine, and without the need for any subsequent heat treatment or other processing. The machine comprises a pair of driven profile rollers 40,42 through which the wire W passes, the wire being converted to a rectangular 35 (or other desired) section. The profiled wire is then fed into a linear guide 44 which is mounted tangentially to a disc-shaped mandrel 46, which is mounted for free rotation about its axis. The rectangular-section wire W is to be wound on its edge, so its major surfaces lie parallel to a vertical plane

(i.e. the plane to which the mandrel axis is perpendicular) and one of its edges comes into contact with the peripheral surface of the mandrel in tangential manner at a point P.

The machine further comprises a forming head 50 carrying two freely-rotatable rollers 52, 54, for bending or curving the wire to the radius of the mandrel 46. Each roller 52, 54 defines a gap, between its periphery and the periphery of the mandrel 46, equal to or slightly greater than the width of the wire between its opposite edges. Roller 52 is positioned with its axis on a radial line from the mandrel axis approximately 10 to 20° from the radius on which the tangential point of contact P lies. Roller 54 is positioned with its axis on a radial line approximately 90° from the radius on which point P lies. The wire guide 44 includes a roller 56 to bear on the outer edge of the wire, and is positioned on a radius of the mandrel at approximately the same angle prior to point P as roller 52 follows point P. As the wire is bent to curved form in passing rollers 52, 54, the wire in the wire guide experiences an outwardly acting force and the roller 56 acts as a reaction for this.

The forming head 50 also includes a channel-shape section 58 through which the wire passes. This section 58 extends as shown in Figure 7, over an arc of approximately 30 to 45° from a point just downstream of the tangential contact point P.

As indicated in Figure 8, the channel section 58 can be displaced in either direction out of the vertical plane in which the wire lies in passing through the wire guide. This can be achieved by pivoting the forming head 50 about an axis 30 A in the vertical plane and parallel to the radius on which the tangential point of contact P lies. The channel section 58 therefore has the effect of deflecting the wire out of its plane as it emerges from the wire guide 44 and is bent towards an arcuate form. The amount and sense of deflection is 35 determined by the position of the forming head 50 about its axis A: the position may be preset, or it may be continuously adjustable during the formation of a spring, for example under the control of a profiled cam. In this manner a spring may be formed with a stiffness or spring rate which varies as required

along its length.

In operation, the wire W is pushed along the wire guide 44 by the drive action of the profile rollers 40, 42, and is bent to arcuate form as it is pushed through the forming head 5 50. As the operation continues, successive turns of a helical coil structure are formed, this helical coil growing and turning around its axis (i.e. the axis of the mandrel) until the profile rollers are stopped or the end of the wire is reached.

10 It will be appreciated that the machine which has been described forms a spring from fully-annealed round-section wire (e.g. stainless steel) without any subsequent heat treatment. The machine will form a spring with a width-to-thickness ratio of the profiled wire of e.g. 3 to 1, which is much greater than 15 hitherto conventional machines.

The machine may be used to form a helical coil spring filter element for the apparatus of Figures 1 and 2. In this case, the profile rollers may form the wire to any of the forms shown in Figures 3 to 5, for example.

Claims

- 1) A filter element which comprises a wire or other elongate element wound into a helical coil in the form of a tension spring with adjacent turns in contact with each other 5 when the coil is suspended freely from one of its ends.
- 2) A filter element as claimed in claim 1, having its opposite end closed.
- 3) A filter element as claimed in claim 1 or 2, in which the spring rate of the elongate element varies progressively 10 along the length of the helical coil.
- 4) A filter element as claimed in any preceding claim, in which the elongate element is generally rectangular in section and is wound with its opposite edges facing radially inwards and radially outwards respectively.
- 15 5) A filter element as claimed in claim 4, in which one side of the elongate element is formed with a longitudinal apex.
- 6) A filter element as claimed in claim 4 or 5, in which a side of the elongate element is formed with projections or 20 indentations spaced apart along its length.
- 7) A filtration apparatus comprising an enclosure having an inlet for fluid to be filtered, an outlet for filtered fluid, and a filter element, the filter element comprising an elongate element wound into a helical coil in the form of a tension spring, the coil having one of its ends registered with 25 the outlet and being freely suspended from that end, and adjacent turns of the coil being in contact with each other.
- 8) A filtration apparatus as claimed in claim 7, including means for backwashing the filter element by passing a flow of 30 fluid through said outlet into the interior of the coil and out of said enclosure through its said inlet.

9) A machine for forming a helical spring, the machine comprising a mandrel, a guide for guiding wire or other elongate element tangentially to the mandrel, drive means upstream of the mandrel for advancing the wire to the mandrel, and a forming means which forms the wire around the mandrel as the wire is advanced.

10) A machine as claimed in claim 9, in which the forming means is arranged to engage the elongate element over a predetermined arc downstream of a point at which the elongate element tangentially engages the mandrel.

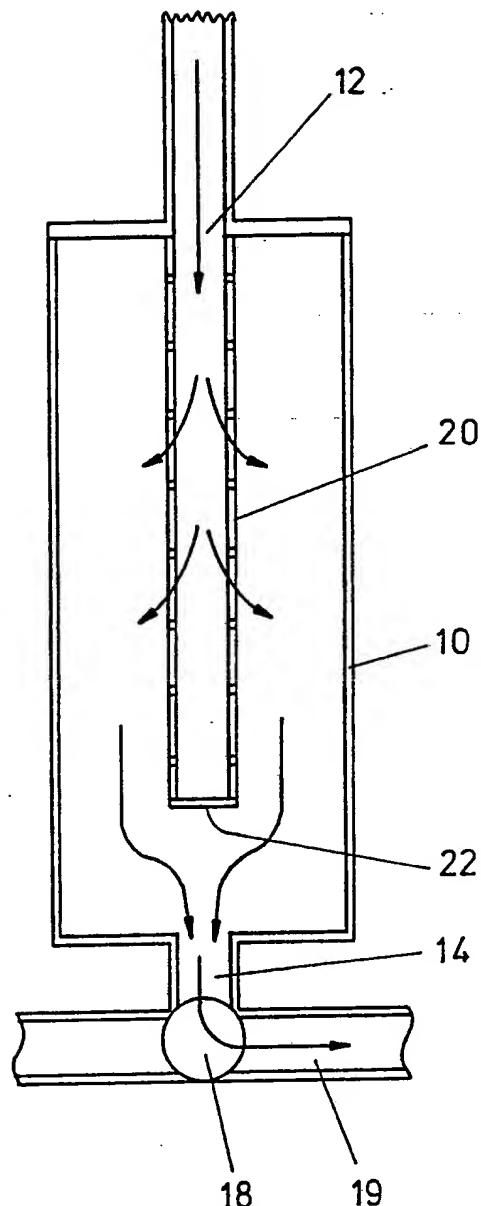
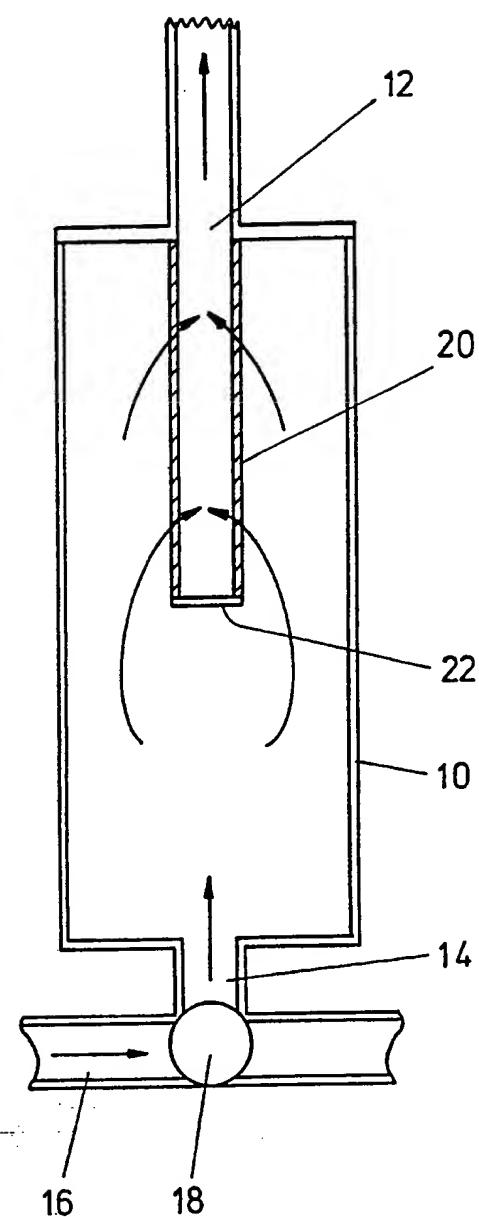
11) A machine as claimed in claim 9, in which the forming means is arranged to engage the elongate element over a said arc of substantially 90°.

12) A machine as claimed in claim 10 or 11, in which the forming means comprises two rollers arranged to engage the elongate element adjacent opposite extremities of said arc.

13) A machine as claimed in any one of claims 9 to 12, in which the forming means is arranged to deflect the elongate element out of a plane to which the mandrel axis is perpendicular, and in which the elongate element lies as it passes into engagement with the mandrel.

14) A machine as claimed in claim 13, in which the forming means is pivotable about an axis lying in said plane, in order to adjust the angle of deflection of the elongate element out of said plane.

-1/3-

FIG. 1FIG. 2

-2/3-

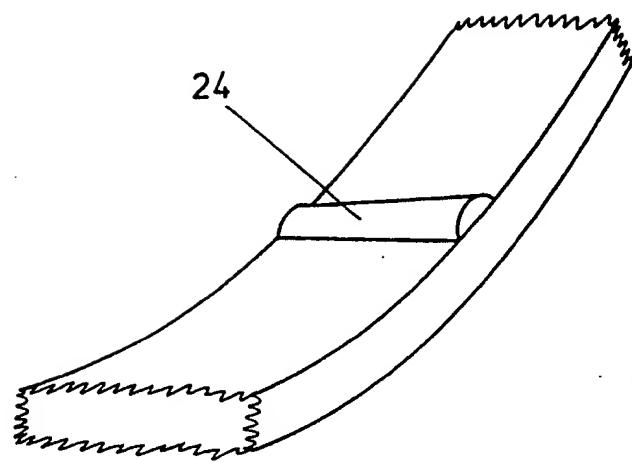


FIG. 3

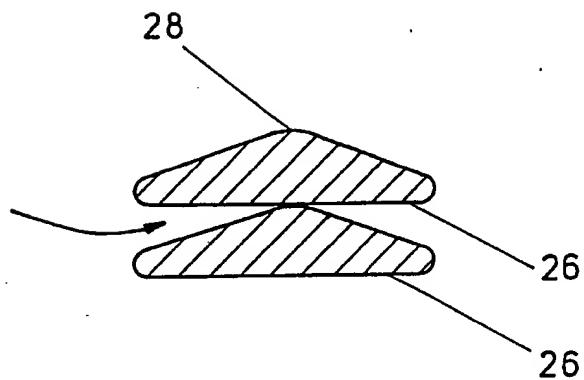


FIG. 4

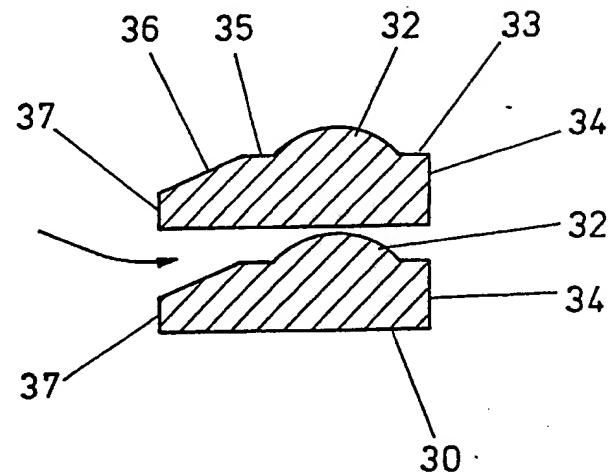


FIG. 5

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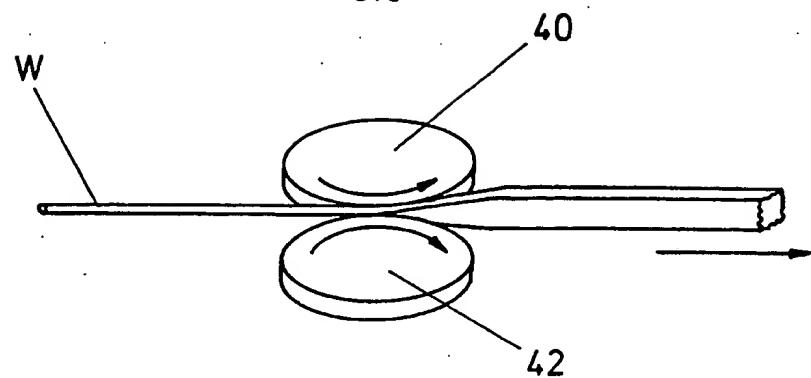


FIG. 6

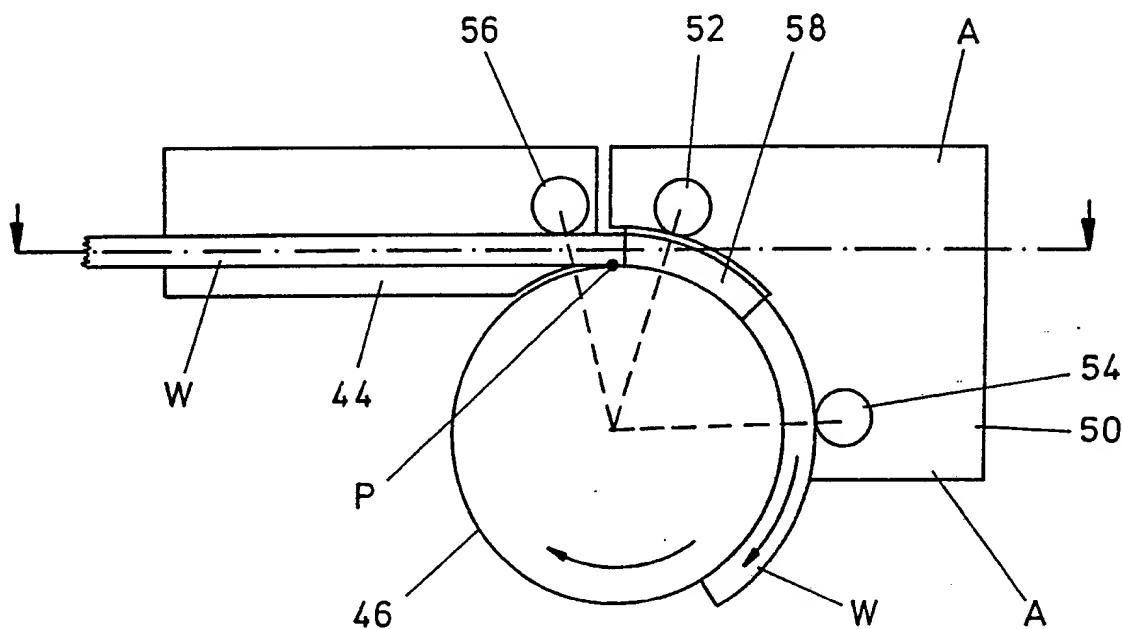


FIG. 7

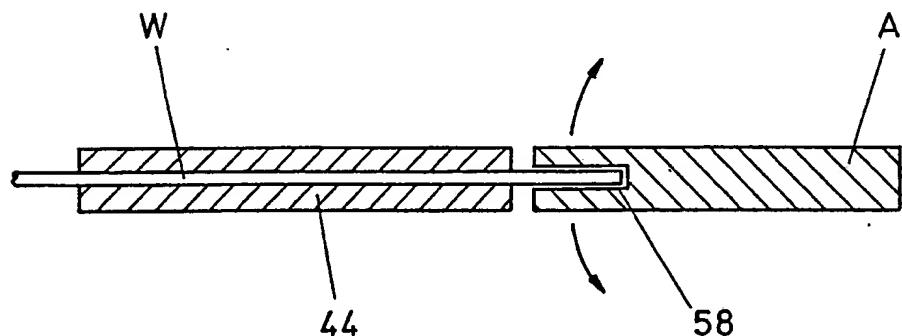


FIG. 8